NOTES

1. Papers selected for inclusion in General Sessions will be available at the Conference in the following official languages of the United Nations: English, French, Russian and Spanish.

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THE ASSESSMENT OF LAND-USE POTENTIAL OF SOILS WITH SPECIAL REFERENCE TO TECHNIQUES APPLICABLE TO UNDER-DEVELOPED ARES

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1. In the scientific assessment of the land-use potential of soils the essential requirements are: a soil classification system; data on soil characteristics; reference standards for the evaluation of data; a system for integrating the various soil values, making allowance for environmental conditions and land use.

SOIL CLASSIFICATION

2. The variety of systems of soil classification now available may be embarrassing to those engaged in the assessment of soil potential but the present situation is a great advance on the past. Formerly the assessment of land-use potential was often made by reference to several features other than soils which for long escaped scientific attention. The reports of the Australian explorers, show the emphasis in the last century on the availability of water, the nature of the vegetation and the topography, the soils then meriting attention only if they were notably sandy, stony, or well-supplied with organic matter.

3. The need for soil classification may not be acknowledged for some time in under-developed areas especially if the land-use relies on the readily available native pastures or forests, but when increased production is sought all the features of the plant environment, including soils, require careful assessment. This may seem self-evident, but it deserves emphasis for there are still unfortunately too many experiences of incorrect interpretations of soils from their native vegetation.

4. The system of soil classification will be chosen to help in estimating the potential land-use of soils on a regional scale or for comparatively small areas, but it is possible that exactly the same system will not be suitable for any different problem areas. In Australia the earliest soil surveys based on the study of soil profiles were made according to the classification of series, type and phase first used in the U.S.A. This system has many advantages in dealing with smaller areas lacking marked variations in climate, elevation, rocks, or vegetation. In dealing with very large areas, however, a soil classification should indicate the most significant groups of soils, as was done so successfully by Prescott[1] who

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[1] Prescott, J.A., The soils of Australia in relation to vegetation and climate, C.S.I.R. Aust. Bull. No. 52, (1931).

introduced the ideas of genetic soil classification conceived in Russia.

5. Many changes in soil classification systems have occurred since 1931 and it is not intended to discuss their relevance to the subject of this paper. The main points for consideration are that the chosen system must be based on the soil profile and must lend itself to field mapping of soils in the area to be studied. The classification system should be chosen also with a view to the correlation of the soils of one area with those elsewhere. Its main use will be in organizing the data on soil characteristics collected either from the field or subsequently in the laboratory.

DATA ON SOIL CHARACTERISTICS

6. The data on soil characteristics needed for assessing the land-use potential of soils may consist entirely of those collected in the field, primarily the information usually presented under the heading of morphological description of soil profiles, but also including information on qualities of the soil surface such as slope, vegetative cover, and drainage. More commonly data are also obtained from laboratory determinations on a limited number of soil samples which are used to characterize still further the different soils. Other data may be obtained by means of glass-house experiments (pot cultures) or by determinations of important physical properties in the field on undisturbed soils.

7. The data obtained by the different methods indicated in the preceeding paragraph are rarely sought for all the different soils to be dealt with in a particular assessment project since preliminary assessments relying on the data collected in the field are ordinarily used to isolate some soils from further attention. In some circumstances, assessments may rely primarily on the field data, together with supplementary data from the laboratory, yet they are often quite satisfactory for those conditions.

8. The determinations obtained from laboratory investigations give quantitative accuracy to particular soil properties, but persons experienced in considering the land use potential of soils will be aware that any determinations apply only to the particular sample, relating to a known section of the soil profile at a given time. If laboratory determinations are really essential for the assessment work, efforts must be made to secure an appropriate number of determinations for the particular soil properties. This immediately introduces questions of time and expense in collecting data on soil characteristics, which can be answered only from the point of view of the relevance of the data to the particular assessment project.

9. It is essential that a decision be made early in the assessment programme regarding the data to be sought. This decision is best reached from the basis of the results of a preliminary study or reconnaissance by which the various possibilities of land use are estimated approximately and the significant problems stated. Thus a preliminary rating of one piece of land as possible for irrigation, another as suitable only for dry-farming, and yet another only for light grazing of native herbage, immediately helps to determine which types of data should be obtained for different soils.

10. Preliminary ratings pay attention particularly to those qualities of the soils and its environment which are determined best or only in

the field. The following exemplify the main considerations in Australia: depth of soil; soil texture profile and occurrence of stones or outcrops; type of plant cover; surface slope in relation to erodibility and drainage; and evidence of flooding or salinity.

11. More detailed assessments of soils depend on laboratory and experimental determinations, the value of which should not be underestimated despite the points made in paragraph 8. Chemical analyses and physical determinations are essential for representing such important soil characteristics affecting plant growth as: available water and oxygen supply within root depth; permeability; supply of mineral nutrients; occurrence of toxic conditions and salinity; and mechanical strength to support plants.

12. The form in which the soil characteristics are to be presented naturally includes maps. The most obvious type needed is one which shows boundaries between the various soil profile classes, but for different purposes maps may be required of topography, drainage groups, soil erosion, types of vegetation, existing land use, or occurrence of saline soils. For extremely detailed studies it may be necessary to map different classes established for different mineral nutrients or physical properties of the soils. Various methods of tabulation, graphs and diagrams are also used for presenting data on soil characteristics.

REFERENCE STANDARDS FOR EVALUATION OF SOIL DATA

13. The evaluation of data on the soils is a matter closely connected with the selection of the data to be sought. For the assessment of land-use potential no set of data should be collected unless a reference standard, however approximate, is available or is made for the purpose. Unfortunately this is not always understood, partly because territorial soil investigations are often conducted for the dual purpose of assessment of land use potential of soils and the collection of all possible scientific data on soils. If an under-developed area already shows some range of intensity of production on different soils, contains a pilot plot for land use, or even gives only historical or perhaps archaeological evidence of land use, then at least there are some references within the area that indicate the potentialities of its soils. Otherwise, reference must be made to soils of similar profile features in nearby districts, or in other countries, due allowance being made for differences in local conditions and in the plants concerned.

14. Useful reference standards may be established from field experiments undertaken specially for assessing the land-use potential of particular soils, or from experiments designed for other purposes but providing also some information of use for such assessments. There are in Australia approximately 50 permanent experiment or research stations concerned with local problems of plant-soil relationships, and which therefore may provide some information for the required reference standards. Most of these stations are in the more densely populated parts of Australia and are controlled by Departments of Agriculture of the different State governments, but in recent years three new stations have been established in northern Australia under the control of the Commonwealth Scientific and Industrial Research Organization (C.S.I.R.O.), to assist the assessment and development of promising areas. Temporary field experiments are often established near permanent experiment stations, in order to give adequate coverage of soils and climatic conditions.

they have provided valuable references for fertility assessments of various soils in southern Australia[2,3,4].

15. Unless reference standards are obtained directly by experiments under the specific conditions and with the particular plant varieties intended for a given area, the reliance on experience with other soils must take into account all the essential differences of environmental conditions and plant requirements. For this reason it is generally necessary to emphasize climatic studies and plant physiology in developing these reference standards. Under Australian conditions where availability of water supply within the rooting zone is often the most important consideration in the assessment of land-use potential, assessments depend on adequate climatological studies.

16. The lack of adequate reference standards for evaluation of soil data is widespread in under-developed areas and is a most serious disadvantage since it reduces the accuracy of any assessment.

INTEGRATION OF THE VALUES FOR SOIL DATA

17. The integration of values for the different soil characteristics is the last process in the assessment of land-use potential of soils. This process has not been standardized and in fact is often attempted without any thoroughly systematic and reasoned, and so examinable, basis. There are some widely known systems, such as the method of land classification for irrigated land use developed by the U.S. Bureau of Reclamation[5] and that for land-capability classification developed by the U.S. Soil Conservation Service.[6] Both of these have considerable value and put stress on matters of prime importance in land-use but they rely ultimately on judgements based on experience of land-use under particular conditions.

18. It is possible to adapt a well-known system for assessment, as was done by the C.S.I.R.O. Division of Land Research and Regional Survey for its current investigations in the Australian Territory of Papua and the Trust Territory of New Guinea, or to devise a system to meet the particular local conditions. Many of the Australian examples of rating the land-use potential of soils emphasize comparatively few of the many soil characteristics, but this is to be expected for under-developed areas. The particular considerations involved in a selection of the Australian projects are shown in Table 1.

CONCLUSIONS

19. The four essential requirements for assessments of soils vary

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2 Riceman, D.S., Mineral deficiency and pasture establishment in the Coonalpyn Downs, South Australia, J. Dept. Agr. S. Aust., 5, 132-140 (1950).

3 Tiver, N.S., and Crocker, R.L., The grasslands of south-east South Australia in relation to climate, soils and developmental history, J. Brit. Grassld. Soc., 6, 29-80 (1951).

4 Newman, R.J., Plant nutrition deficiencies in Victorian pasture soils, J. Dept. Agric. Vic., 54, 337-345,347 (1956).

5 U.S. Dept of the Interior, Bureau of Reclamation Manual, Vol. 5, Irrigated Land Use, Pt. 2, Land Classification, Washington (1953).

6 Klingebiel, A.A., and Montgomery, P.H., Land-capability Classification, Agriculture Hadbk. No. 210, Soil Conservation Service, U.S. Dept. Agric. (1961).

TABLE 1

AUSTRALIAN EXPERIENCES OF ASSESSMENT OF LAND-USE POTENTIAL OF SOILS

PROJECT NAME AND AREA	LAND USE	SOIL CLASSIFICATION	BASIS FOR ASSESSMENT OF LAND USE POTENTIAL
Lakes District, W.A.[a] (357 sq mi)	Wheat, Stock Raising	Series, Type and Phase	Texture Profile, Structure, Salinity, Local Experience.
County Grey, S.A.[b] (500 sq mi)	Plantation Forestry, Stock Raising, Cereals	Pedogenic Type, Soil Type and Phase	Local Experience, Texture Profile, Nutrient Status, Topography and Drainage
Coomealla, N.S.W.[c] (26 sq ml)	Irrigated Horticulture	Series, Type and Phase	Local Experience, Texture Profile, Topography and Drainage, Salinity, Infiltration Characteristics.
Lower Burdekin Valley, Qld.,[d] (12705 sq mi)	Irrigated Tropical crops, Stock Raising	Series, Type and Phase	Local Experience, Related Australian Experience, Texture Profile, Soil depth, Topography and Drainage, Salinity, Infiltration Characteristics.
Shire of Kowree, Vic.,[e] (2114 sq mi)	Stock Raising, Cereals	Great Soil Groups	Local and related Australian Experience, Texture Profile, Nutrient status, Salinity, Topography and Drainage.
Katherine - Darwin region, N.T.[f,g] (27,000 sq mi)	Stock Raising, Tropical crops	Great Soil Groups and Families	Soil Texture Profile, Soil Depth, Topography and Drainage, Rainfall, Local Experience.
Flinders Is., Tas.[h] (513 sq mi)	Stock Raising	Soil Association Series and Phase	Local Experience, Topography and Drainage, Texture Profile, Soil Depth, Exposure to wind, Acidity, Salinity.

[a] Teakle, L.J.H., Southern, B.L., and Stokes, S.J., Soil Survey of the Lakes District, W.A. J. Dept. Agric. W. Aust. 17 (2nd Ser.), 251-294 (1940).
[b] Stephens, C.G., Crocker, R.L., Butler, B., and Smith, R., A Soil and land use survey of the Hundreds of Riddoch, Hindmarsh, Grey, Young and Nangwarry, County Grey, South Australia, C.S.I.R. Aust. Bull.No.142. (1941).
[c] Northcote, K.H., and Boehm, E.W. The Soils and horticultural potential of portion of the Coomealla Irrigation Area, New South Wales, C.S.I.R. Aust. Soils and Land Use Series No.1 (1949).
[d] Hubble, G.D., and Thompson, C.H. The soils and land use potential of the lower Burdekin Valley, North Queensland, C.S.I.R.O. Aust. Soils and Land Use Ser. No. 10, (1953).

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considerably in their availability. No difficulty should be found in obtaining a soil classification system, but care is needed to select one appropriate for the area and the type of work, especially mapping, involved. The collection of data on soil characteristics is a straightforward matter, once the significant characteristics have been determined, but it is often laborious and time-consuming. Reference standards for the evaluation of the data are rarely available in detailed form; their establishment requires considerable attention to problems of soil science, climatology and plant physiology, and generally involves local experimentation. Ready-made systems for integrating the various soil values to give the required assessment of land-use potential are not yet available for detailed assessments, and even for the more general assessments they may not be transferable readily from one environment to another.

20. Each country has certain fairly common problems which may colour the assessment of the local land-use potential of soils. In Australia great attention must be paid to climatic features in making comparisons with the experience of soils either in other parts of Australia or overseas. There is also the problem of slightly to moderately saline soils, widespread in the drier fringe of southern Australia. These are affected by the different leaching conditions established after the substitution of cereal growing or irrigated agriculture for the predominantly sclerophyll mallee scrub, with the consequent tendency for the development of secondary salinization on parts of the lowlands which serve as salt-traps. Assessments of soil fertility are coloured also by the significance of soils associated with laterite and by common Australian practices, especially the widespread reliance on a range of artificial fertilizers the distribution of which depends on highly mechanized agricultural methods.

21. These features may prevent any very direct use of Australian experiences in land-use assessment in other under-developed countries, but the various requirements for such assessment, dealt with in this paper, do appear to have general relevance. The principle followed in Australia of working from a more general to a more particular assessment also has general application and, of course, is not a local development.

22. Any assessments should be regarded only as approximations based on existing knowledge and techniques. Greater accuracy in this work is to be expected in future with considerably deeper knowledge of soils and other factors in land-use.

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[e] Blackburn, G., and Gibbons, F.R., A reconnaissance survey of the soils of the Shire of Kowree, Victoria, C.S.I.R.O. Aust. Soils and Land Use Ser. No. 17, (1956).

[f] Christian, C.S., and Stewart, G.A., General report on survey of Katherine - Darwin Region, 1946, C.S.I.R.O. Aust. Land Res. Ser. No.1. (1953).

[g] Stewart, G.A., The soils of the Katherine - Darwin Region, Northern Territory, C.S.I.R.O. Aust. Soil Pub. No.6, (1956).

[h] Dimmock, G.M. The soils of Flinders Island, Tasmania, C.S.I.R.O. Aust. Soils and Land Use Ser. No.23, (1957).

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